METHOD FOR EMBEDDING INFORMATION AND EXTRACTING THE SAME

CROSS-REFERENCES TO RELATED APPLICATIONS

This application claims priority from Japanese

5   Patent Application No. 11-153672 filed on June 1, 1999 and

No. 11-75007 filed on March 19, 1999, the entire contents

of which are incorporated herein by reference for all

purposes.   This application relates to the U.S. Patent

Application 09/388,447, filed on September 2, 1999, which

10   claims priority from Japanese Patent Applications No. 10-

343119 filed on December 2, 1998, No. 11-075006 filed on

March 19, 1999, and No. 11-153385 filed on June 1, 1999.

BACKGROUND OF THE INVENTION

15   The present invention relates to a technique of

digital watermarking of digital data, in particular,

multimedia data such as image data.

Recently, the technique of digital watermarking has

20   the attention from the viewpoint of copyright protection of

multimedia data such as image data.   By the technique of

digital watermarking, given information is embedded in

multimedia data, and that given information can not be

extracted from the multimedia data in question at least

25   without employing a given rule.   Using this technique,

information, for example, on a purchaser of image data is

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embedded in an invisible form in the image data itself according to a given rule. When the data is copied illegally, then, by extracting the embedded information from the illegally-copied data according to the above-

5   mentioned given rule, it is possible to specify a person (i.e., the purchaser) who has carried out the illegal copying.

Image data having embedded digital watermark information may be subject to various image processing such

10   as shifting, scaling, and rotation. Thus, it is desired that a given information can be extracted from multimedia data even in those cases.

SUMMARY OF THE INVENTION

15   According to the present invention, even if image data having digital watermark information has been subjected to the above-mentioned image processing, it is possible to specify positions in which the digital watermark information is embedded, in the image data in

20   question.

The present invention provides a method of embedding digital watermark information, in which image data is divided into a plurality of areas S each consisting of M × N ($1 \leq M$, N) pixels, and each bit of digital watermark

25   information $b_1 - b_n$ ($2 \leq n$) is embedded in at least one of the mentioned plurality of areas S, wherein:

the mentioned digital watermark information $b_1 - b_n$ is embedded in the image data such that:

a plurality of groups, each having a predetermined array consisting of areas $T_1 - T_n$ in which the mentioned digital watermark information $b_1 - b_n$ is respectively embedded and areas $H_1 - H_m$ ($1 \leq m$) in which information is not embedded, are located according to a predetermined rule; and

each of the mentioned areas S is allocated to some one of the mentioned areas $T_1 - T_n$ and $H_1 - H_m$.

According to the above-described mode of the invention, the groups G each having the predetermined array consisting of the areas $T_1 - T_n$ in which the digital watermark information $b_1 - b_n$ is respectively embedded and the areas $H_1 - H_m$ ($1 \leq m$) in which information is not embedded, are located according to a predetermined rule, in such a manner that each of the areas S obtained by dividing the image data is necessarily allocated some one of the mentioned areas $T_1 - T_n$ and $H_1 - H_m$.

Thus, even when image shift (i.e., processing of changing the origin in the X-Y coordinates for specifying a location of each pixel constituting the image data in question) is carried out on the image data in which the digital watermark information $b_1 - b_n$ is embedded in such a manner, and accordingly, the locations of the areas T1 - Tn in which the digital watermark information is embedded are

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changed in the X-Y coordinates, it is possible to recognize each of the groups located on the image data by detecting the areas H_1 - H_m in which information is not embedded, in the areas S, and based on the values of X-Y coordinates of the detected areas H_1 - H_m on the image data. In each group, the areas T_1 - T_n in which digital watermark information b_1 - b_n is respectively embedded and the areas H_1 - H_m in which the digital watermark information is not embedded are located in the predetermined arrangement. As a result, for each group, it is possible to specify the areas T_1 - T_n in which the digital watermark information b_1 - b_n is respectively embedded.

Further, the present invention provides a method of embedding digital watermark information, in which image data is divided into a plurality of areas S each consisting of M × N ($1 \le$ M, N) pixels, and each bit of digital watermark information b_1 - b_n ($2 \le$ n) is embedded in at least one of the mentioned areas S, wherein:

a plurality of groups, each having a predetermined array consisting of areas T_1 - T_n in which the mentioned digital watermark information b_1 - b_n is respectively embedded, areas J_1 - J_k ($1 \le$ k) in which information p_1 - p_k specifying an embedding format for embedding the digital watermark information b_1 - b_n in said areas T_1 - T_n, and areas H_1 - H_m ($1 \le$ m) in which information is not embedded, are located according to a predetermined rule; and

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each of the mentioned areas S is allocated to some one of the mentioned areas T_1 - T_n, J_1 - J_k, and H_1 - H_m; in embedding the mentioned digital watermark information b_1 - b_n and the mentioned information p_1 - p_k specifying the

5 mentioned embedding format, in the image data.

According to the above-described mode of the present invention, the groups, each having the predetermined array consisting of the areas T_1 - T_n in which the digital watermark information b_1 - b_n is respectively embedded, the

10 areas J_1 - J_k in which the information p_1 - p_k specifying the embedding format for the mentioned digital watermark information b_1 - b_n in the mentioned areas T_1 - T_n is embedded, and the areas H_1 - H_m in which information is not embedded, are located according to the predetermined rule

15 such that each of the areas S obtained by dividing the image data is necessarily allocated to some one of the mentioned areas T_1 - T_n, J_1 - J_k, and H_1 - H_m.

Thus, even when image shift is carried out on the image data in which the digital watermark information b_1 -

20 b_n is embedded in such a way, and accordingly, X-Y coordinate locations of the areas T_1 - T_n in which the digital watermark information b_1 - b_n is embedded are changed, it is possible to recognize each of the groups located on the image data by dividing the image data on

25 which this image shift has been carried out into a plurality of areas S and by detecting the areas H_1 - H_m in

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which information is not embedded from the areas S, and based on the X-Y coordinates values of the detected areas H_1 - H_m on the image data.

Further, in the present mode, for each group, the information p_1 - p_k specifying the embedding format for the digital watermark information b_1 - b_n in the areas T_1 - T_n is embedded in the areas J_1 - J_k. Accordingly, even when an embedding format for the digital watermark information b_1 - b_n is changed for each group, it is possible to extract the digital watermark information b_1 - b_n from the image data.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be more apparent from the following detailed description, when taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a block diagram showing an digital watermark information embedding apparatus 1 used in a digital watermark system to which an embodiment of the present invention is applied;

Fig. 2 is a view for explaining an operation principle of a block dividing part 103 of the digital watermark information embedding apparatus 1 shown in Fig. 1;

Fig. 3 is a view for explaining an operation principle of an information embedding part 104 of the digital watermark information embedding apparatus 1 shown

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in Fig. 1;

Fig. 4 is a view for explaining the operation principle of the information embedding part 104 of the digital watermark information embedding apparatus 1 shown in Fig. 1;

Fig. 5 is a view for explaining the operation principle of the information embedding part 104 of the digital watermark information embedding apparatus 1 shown in Fig. 1;

Fig. 6 is a view for explaining the operation principle of the information embedding part 104 of the digital watermark information embedding apparatus 1 shown in Fig. 1;

Fig. 7 is a view showing an example of the hardware configuration of the digital watermark information embedding apparatus 1 shown in Fig. 1;

Fig. 8 is a flowchart for explaining operation of the digital watermark information embedding apparatus 1 shown in Fig. 1;

Fig. 9 is a block diagram showing a digital watermark information extracting apparatus 3 used in a digital watermark system to which an embodiment of the present invention is applied;

Fig. 10 is a view for explaining an operation principle of a group recognizing part 304 of the digital watermark information extracting apparatus 3 shown in Fig.

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Fig. 11 is a view for explaining the operation principle of the group recognizing part 304 of the digital watermark information extracting apparatus 3 shown in Fig.

5   9;

Fig. 12 is a flowchart for explaining operation of the digital watermark information extracting apparatus 3 shown in Fig. 9;

Figs. 13A and 13B are flowcharts for explaining a

10   difference in processing burdens between the case (Fig. 13A) in which the method of repeating the same transformation processing as the left-right reversal, scaling processing, and rotation processing that might have been carried out on image data until the digital watermark

15   information b_1 - b_n is extracted from the image data is applied to the transformation by image shift processing and the case (Fig. 13B) in which the mentioned method is combined with the extract method of the present embodiment;

Fig. 14 is a view for explaining a variation of a

20   location pattern for groups G on image data, used in the information embedding part 104 of the digital watermark information embedding apparatus 1 shown in Fig. 1;

Fig. 15 is a view for explaining a state in which reversal processing has been carried out on the image data

25   having the location pattern of the groups G shown in Fig. 14;

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Fig. 16 is a view for explaining a state in which 180-degree rotation processing has been carried out on the image data having the location pattern of the groups G shown in Fig. 14;

5   Fig. 17 is a view for explaining a principle of embedding and extracting information in and from image data by a digital watermarking technique; and

Fig. 18 is a view for explaining problems in information embedding and extracting processing on image

10   data by a digital watermark technique, in the case that image shift has been carried out on the image data.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 17 is a view for explaining a method of

15   embedding and extracting information in and from image data by a digital watermarking technique.

As shown in the figure, in information embedding processing, with respect to each bit b_i ($0 \le i \le n$) out of bits b_1 - b_n constituting information that is desired to be

20   embedded, brightness of each of pixels positioned in predetermined areas Q_1 - Q_m in the image data is changed to increase by U when the bit in question is 1, and to decrease by U when it is 0. By carrying out this processing for every bit b_1 - b_n while changing positions of

25   the areas in which the bit in question is embedded, digital watermark information is embedded in the image data.

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In processing of extracting the above-mentioned embedded digital watermark information, with respect to a bit b_i $(0 \leq i \leq n)$ out of the bits $b_1 - b_n$ constituting the embedded information, an average brightness F of pixel data

5   is obtained for each of the above-mentioned predetermined areas $Q_1 - Q_m$ of the image data, so as to obtain the sum total ΣF of these averages. Further, an average brightness R of pixel data is obtained for respective peripheral areas adjacent to the above-mentioned predetermined areas $Q_1 - Q_m$,

10   so as to obtain the sum total ΣR (Reference Value) of these averages. When $\Sigma F - \Sigma R \geq Th$ (where, Th differs depending on required error rates, and here it is assumed that $Th = 1/2 \times U \times m$ (m: the number of the areas Q in which b_i is embedded)), then it is judged that $b_i = 1$. When, $\Sigma F - \Sigma R$

15   $\leq -Th$, then it is judged that $b_i = 0$. And, when $-Th < \Sigma F - \Sigma R < Th$, then it is judged that information is not embedded in the above-mentioned predetermined areas $Q_1 - Q_m$. This processing is carried out for every bit $b_1 - b_n$, so as to extract the digital watermark embedded in the image data.

20   Digital watermarking technique is described in detail in Proceedings of the 56th National Convention of IPSJ 1998, pages 3-37 - 3-38.

In Fig. 17, it is assumed that the origin O of the X-Y coordinates for specifying a position of each pixel

25   constituting image data is set at the upper left vertex of the image data in question. Here, as shown in Fig. 18,

when an upper portion of image data in which digital
watermark information is embedded is cut, then, respective
embedded positions in the X-Y coordinates of the bits b_1 -
b_n constituting the digital watermark information are

5   changed.

According to the present invention, even in such a
case, it is possible to extract each bit constituting
digital watermark information.

Now, a first embodiment of the present invention

10   will be described in the following.

First, there is described a digital watermark
information embedding apparatus used in a digital watermark
system to which the present embodiment is applied.

Fig. 1 is a block diagram showing the digital

15   watermark information embedding apparatus used in the
digital watermark system to which the first embodiment of
the present invention is applied.

As shown in the figure, the digital watermark
information embedding apparatus 1 of the present embodiment

20   comprises a processing part 100 and a storage part 110.

The processing part 100 comprises: an input-output
part 101 for inputting and outputting image data, digital
watermark information to be embedded in image data, and
image data in which digital watermark information is

25   embedded; a control part 102 that controls each part of the
digital watermark information embedding apparatus 1 in a

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unified manner; a block dividing part 103; and an information embedding part 104.

The storage part 110 comprises: an image hold part 111 that holds image data inputted through the input-output part 101; a watermark information hold part 112 that holds digital watermark information b_1 - b_n ($2 \leq n$) to be embedded in the image data inputted through the input-output part 101 and held in the image hold part 111; a watermarked image hold part 113 that holds image data in which the digital watermark information b_1 - b_n is embedded; and a group array/location rule storage part 114 that stores a rule of embedding the digital watermark information b_1 - b_n in the image data.

The block dividing part 103 divides image data held in the image hold part 111 into a plurality of areas S each consisting of M × N ($1 \leq$ M, N) pixels, according to the group array/location rule stored in the group array/location rule storage part 114, as shown in Fig. 2.

The information embedding part 104 embeds the digital watermark information b_1 - b_n, which is held in the watermark information hold part 112, in the image data held in the image hold part 111, according to the group array/location rule stored in the group array/location rule storage part 114.

In detail, the digital watermark information b_1 - b_n and information p that specifies embedding format are

embedded in the image data as follows. Namely, groups G, each of which has a predetermined array, are located on the image data so as to cover all the image data. The mentioned array consists of: areas T_1 - T_n in which the

5 digital watermark information b_1 - b_n is respectively embedded; an area J in which the information p that specifies embedding format of the digital watermark information b_1 - b_n in the areas T_1 - T_n is embedded; and an area H in which information is not embedded. And, a

10 plurality of areas S obtained by division of the image data by the block dividing part 103 are each allocated to some one of the areas T_1 - T_n, J, and H, without fail.

Here, embedding of the digital watermark information b_1 - b_n and the information p in the image data is carried

15 out by increasing or decreasing brightness of the image data in the corresponding area by U, according to a value (0, 1) of a bit of the information, similarly to the conventional technique. However, in the present embodiment, as a pixel data brightness

20 increasing/decreasing direction pattern depending on a bit value of information to be embedded, two kinds of patterns are prepared in order that extraction of information embedded in a certain area S of each group G is not affected by information embedded in the areas S located on

25 the four sides of the area S in question. The information p is used for specifying this brightness

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increasing/decreasing direction pattern.

Here, the pixel data brightness
increasing/decreasing direction pattern applied to each
group G is set as follows. Namely, for example, in the
case that the groups G each consisting of 3 × 3 (nine in
total) areas S_1 - S_9 are located to cover all the image data
as shown in Fig. 3, there are prepared a first pattern in
which pixel data brightness increasing/decreasing
directions for a bit value are same for all the areas S_1 -
S_9 within a group G, and a second pattern in which pixel
data brightness increasing/decreasing directions are
opposite between vertically- or laterally-adjacent areas S,
as shown in Fig. 4. Then, as shown in Fig. 5, the patterns
are set on the image data so that mutually different
brightness increasing/decreasing direction patterns are
applied to vertically- or laterally-adjacent groups G.

Further, allocation of the areas T_1 - T_n, J, and H
to the areas S within a group G is carried out so as to
satisfy the following conditions.

Namely, extraction of the information p, which
specifies the applied brightness increasing/decreasing
direction pattern, from the image data should be carried
out before the brightness increasing/decreasing direction
pattern applied to the group G is ascertained.
Accordingly, the area J in which the information p is
embedded is allocated to an area S whose image data

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brightness increasing/decreasing direction for a bit value is same for all the brightness increasing/decreasing direction patterns. In the example shown in Fig. 4, the area J is allocated to some one of the areas S_1, S_3, S_5, S_7,

5   and S_9.

Further, with respect to the area H in which information is not embedded, in order to detect the fact that information is not embedded in this area, it is necessary that the detection is not affected by brightness

10 increasing/decreasing owing to information embedded in the areas located on the four sides of the area in question. Therefore, the area H in which information is not embedded is allocated to such an area S that, according to the employed brightness increasing/decreasing direction

15 patterns, image data brightness increasing/decreasing directions for a bit value are reversed in the areas located on the four sides of the area in question. In the example shown in Fig. 4, the area H is allocated to some one of the areas S_1, S_3, S_5, S_7, and S_9.

20 The areas T_1 - T_n in which the digital watermark information b_1 - b_n is embedded are necessarily allocated to the other areas S_1 - S_9 than the areas to which the areas J and H have been allocated. In that case, it is desirable to note the following, in order that an error is not caused

25 in the below-described detection of the area H in which information is not embedded.

Namely, in the case that the areas T_i ($1 \leq i \leq n$) are allocated to areas S in which the image data brightness increasing/decreasing direction for a bit value is reversed depending on the brightness increasing/decreasing direction patterns, when brightness averages F for pixel data within the area T_i are obtained respectively for the groups G and added, brightness increase or decrease owing to a bit value of watermark information b_i embedded in that area T_i may be canceled. Accordingly, their total sum ΣF does not reflect the brightness increase or decrease owing to the information embedding.

On the other hand, image data brightness increase/decrease directions for a bit value in the adjacent areas located on the four sides of the area T_i in question are same for all the brightness increasing/decreasing direction patterns. Accordingly, with respect to these adjacent areas, the total sum ΣR of image data brightness averages R obtained respectively for the groups G reflects the brightness increase or decrease owing to the bit value of the embedded information. Thus, generally, there arises a difference to some degree between the total sum ΣF and the total sum ΣR.

However, in the case that bit values of information embedded in the adjacent areas located on the four sides of the area T_i in question are 1 for two values and 0 for the remaining two areas, then, when the brightness average R of

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the pixel data embedded in these adjacent areas is taken,
brightness increase or decrease is cancelled. Accordingly,
the difference between the total sum ΣF and the total some
ΣR becomes small, and there is the possibility that the

5   area T_i in question is erroneously detected as the area H
in which information is not embedded. Thus, when the area
Ti is allocated to an area S for which image data
brightness increasing/decreasing direction for a bit value
is reversed according to the employed brightness

10   increasing/decreasing direction patterns, the area H in
which information is not embedded is allocated to one of
the adjacent areas located on the four sides of the area S
in question. As a result, the brightness average R of the
pixel data embedded in these adjacent areas reflects the

15   brightness increase or decrease owing to a bit value of the
embedded information.

      In the example shown in Figs. 4 and 5, when the
areas T_1 - T_n, J, and H are allocated to the areas S_1 - S_9
within a group G, for example, as shown in Fig. 6, the

20   above-described conditions are satisfied.

      Next, a hardware configuration of the digital
watermark information embedding apparatus to which the
present embodiment is applied will be described.

      Fig. 7 is a view showing an example of the hardware

25   configuration of the digital watermark information
embedding apparatus 1 shown in Fig. 1.

As shown in the figure, the digital watermark information embedding apparatus of the present embodiment can be implemented on an information processing apparatus of general construction comprising a processor (CPU) 201, a memory 202, an external storage unit 203 such as a hard disk unit, another external storage unit 204, an input unit 205 such as a keyboard, an output unit 206 such as a display, and an interface 207 with the external storage units and input and output units. Here, each part of the processing part 100 shown in Fig. 1 is realized as a process that is substantiated on the information processing apparatus when the CPU 201 executes a program loaded onto the memory 202. Further, in this case, the memory 202 and the external storage units 203, 204 are used as the storage part 110 shown in Fig. 1.

The above-mentioned program that is executed by the CPU 201 for substantiating the digital watermark information embedding apparatus of the present embodiment on the information processing apparatus is stored in the external storage unit 203 in advance and loaded onto the memory 202 as the need arises, so as to be executed by the CPU 201. Or, the program may be loaded onto the memory 202 from a portable storage medium 208 such as CD-ROM through the external storage unit 204 that handles the mentioned portable storage medium 208, and then, executed by the CPU 201. Or, the program may be once installed in the external

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storage unit 203 from a portable storage medium 208 through the external storage unit 204, and thereafter, loaded onto the memory 202 from the external storage unit 203 as the need arises, so as to be executed by the CPU 201. Or, the

5 program may be once downloaded into the external storage unit 203 from a network through a network connecting apparatus (not shown) and loaded onto the memory 202, or directly loaded onto the memory 202 through a network, so as to be executed by the CPU 201.

10 Next, operation of the digital watermark information embedding apparatus to which the present embodiment is applied will be described.

Fig. 8 is a flowchart for explaining operation of the digital watermark information embedding apparatus 1

15 shown in Fig. 1. This flow is started when the control part 102 cooperates with the input-output part 101 to make image data and digital watermark information b_1 - b_n held in the image hold part 111 and the watermark information hold part 112, respectively.

20 First, as previously described referring to Fig. 2, the block dividing part 103 divides the image data held in the image hold part 111 into a plurality of areas S each consisting of predetermined M × N (1 ≤ M, N) of pixels, according to the rule stored in the group array/location

25 rule storage part 114 (Step S1001).

Next, as previously described referring to Figs. 2 -

5, the information embedding part 104 establishes a
brightness increasing/decreasing direction pattern (first
pattern or second pattern) applied to each group G,
according to the rule stored in the group array/location
5   rule storage part 114 (Step S1002). Then, as previously
described referring to Fig. 6, groups G are located one
after another to cover all the image data, according to the
rule stored in the group array/location rule storage part
114. Each of the groups G has a predetermined array
10   consisting of the areas T_1 - T_n in which the digital
watermark information b_1 - b_n is embedded respectively, the
area J in which the information p specifying brightness
increasing/decreasing direction patterns is embedded; and
the area H in which information is not embedded. And, the
15   areas T_1 - T_n, J, and H are allocated to a plurality of
areas S obtained by division of the image data by the block
dividing part 103 such that each area S is necessarily
allocated with some one of the areas T_1 - T_n, J, and H (Step
S1003).

20   Next, the information embedding part 104 reads one
bit b_i (1 ≤ i ≤ n) of the digital watermark information
from the watermark information hold part 112 (Step S1004).
Then, the digital watermark information b_i, which has been
read, is embedded in the corresponding area T_i of each
25   group G allocated in Step S1003, by increasing or
decreasing brightness of the pixel data within the area T_i

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in question by U depending on the bit value of the digital
watermark information b_i, according to the brightness
increasing/decreasing direction pattern of each group G
established in Step S1002 (Step S1005).

5   Next, when the processes of the above-described
Steps S1004 and S1005 are carried out for all the digital
watermark information b_1 - b_n held in the watermark
information hold part 112 (Step S1006), then the
information embedding part 104 embeds the information p
10   identifying the brightness increasing/decreasing direction
pattern (first or second pattern) established in Step S1003
(Step S1007). Here, as described above, with respect to
the embedding of the information p in the area J, the pixel
data brightness increasing/decreasing direction for a bit
15   value is same for all the brightness increasing/decreasing
direction patterns.

When embedding of the information p in the area J of
each group G is finished, namely, when embedding of the
digital watermark information b_1 - b_n and the information p,
20   which specifies the embedding format of the digital
watermark information for each group G, in the image data
are finished, then the watermarked image hold part 113 is
made to hold the processed image data, to finish the
present flow. The image data held in this image hold part
25   113 is outputted as the watermarked image data through the
input-output part 101, as the need arises.

Next, there will be described a digital watermark information extracting apparatus used in a digital watermark system to which the present embodiment is applied.

5   Fig. 9 is a block diagram showing the digital watermark information extracting apparatus used in the digital watermark system to which an embodiment of the present invention is applied.

As shown in the figure, the digital watermark

10   information extracting apparatus 3 of the present embodiment comprises a processing part 300 and a storage part 310.

The processing part 300 comprises: an input-output part 301 for inputting and outputting image data in which

15   digital watermark information is embedded and the digital watermark information extracted from that image data; a control part 302 for controlling each part of the digital watermark information extracting apparatus 3 in a unified manner; a block dividing part 303; a group recognizing part

20   304; and an information extracting part 305.

The storage part 310 comprises: an image hold part 311 for holding image data in which digital watermark information b_1 - b_n is embedded and which is inputted through the input-output part 301; a group array/location

25   rule storage part 312 for storing a rule of extracting the digital watermark information b_1 - b_n from the image data;

and a watermark information hold part 313 for holding the digital watermark information b_1 - b_n extracted from the image data. Here, the rule stored in the group array/location rule storage part 312 is same as the rule stored in the group array/location rule storage part 114 of the digital watermark information embedding apparatus 1 shown in Fig. 1.

The block dividing part 303 divides image data embedded with the digital watermark information b_1 - b_n, which is held in the image hold part 311, into a plurality of areas S each consisting of M × N (1 ≤ M, N) pixels in the same manner as the block dividing part 303 of the digital watermark information embedding apparatus 1 shown in Fig. 1. Here, the size (M × N) of the area S is set as the area S established in the block dividing part 303 of the digital watermark information embedding apparatus 1 shown in Fig. 1.

The group recognizing part 304 recognizes respective locations of a plurality of groups G located on the image data embedded with the digital watermark information b_1 - b_n, which is held in the image hold part 311, according to the rule stored in the group array/location rule storage part 312. In detail, this is carried out in the following manner.

First, temporary groups G' each having the same size and shape as the group G specified by the rule stored in

the group array/location rule storage part 312 are located

on the image data divided into a plurality of areas S by

the block dividing part 303, in a predetermined manner

specified by the rule stored in the group array/location

5   rule storage part 312 (namely, located so as to cover all

the image data).

Next, for respective areas S of the temporary groups

G' located on the image data as described above, it is

examined if information is embedded or not, so as to detect

10   the area H in which information is not embedded.

In detail, for example, the case that the temporary

groups G' each having the same size and shape as the group

G consisting of 3 × 3 (nine in total) areas S_1 - S_9 as shown

in Fig. 3 are located to cover all the image data may be

15   considered. In that case, with respect to the area S_i (1 ≤

i ≤ 9), a brightness average F for pixel data within the

area S_i in question is obtained for each temporary group

G', and the total sum ΣF of these averages is obtained.

Further, a brightness average R for pixel data in the

20   adjacent areas located on the four sides of the area S_i in

question is obtained, and the total sum ΣR of these

averages is obtained. Then, if the condition |ΣF - ΣR| ≥

Th (where Th differs depending on required error rates,

and, for example, it is assumed that Th = 1/2 × U × m (m:

25   the number of the temporary groups G' located on the image

data)) is satisfied, it is judged that some information is

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embedded in the area S_i in question. On the other hand, if the condition $|\Sigma F - \Sigma R| <$ Th is satisfied, it is judged that information is not embedded in the area S_i in question. This process is carried out for all the areas S_1

5 - S_9 so as to detect the area in which information is not embedded.

As described above, with respect to an area S that is allocated to another area than the area H in which information is not embedded, when the image data brightness

10 increasing/decreasing direction for a bit value is same for all the brightness increasing/decreasing direction patterns, then, the total sum ΣF of the pixel data brightness averages F obtained for that area respectively in the temporary groups G' reflects brightness increase or

15 decrease owing to information embedded in the area in question. On the other hand, with respect to the total sum ΣR of the pixel data brightness averages R obtained for the adjacent areas located on the four sides of the area in question respectively in the temporary groups G', image

20 data brightness increasing/decreasing direction for bit values in these adjacent areas is reversed depending on the brightness increasing/decreasing direction patterns. Accordingly, brightness increase or decrease owing to embedded information is cancelled. As a result, there is

25 generated a difference between the total sum ΣF and the total sum ΣR to some degree.

25

Further, with respect to an area S that is allocated to another area than H in which information is not embedded, when the image data brightness increasing/decreasing direction for a bit value is reversed

5   according to the employed brightness increasing/decreasing direction patterns, then, brightness increase or decrease owing to information embedded in the area S in question is cancelled in the total sum ΣF of the pixel data brightness averages F obtained for that area respectively in the

10   temporary groups G'. On the other hand, the total sum ΣR of the pixel data brightness averages R obtained for the adjacent areas located on the four sides of the area in question respectively in the temporary groups G' reflects brightness increase or decrease owing to information

15   embedded in these areas. The reason is that the image data brightness increasing/decreasing direction for bit values in these adjacent areas is same for all the brightness increasing/decreasing direction patterns, and one of these four adjacent areas is the area H in which information is

20   not embedded. Thus, the total sum ΣR reflects brightness increase or decrease owing to the information embedded in these three areas other than the area H. As a result, there arises a difference to some degree between the total sum ΣF and the total sum ΣR.

25   In contrast, the area H in which information is not embedded is allocated to an area S for which image data

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brightness increasing/decreasing direction for bit values in the adjacent areas located on the four sides of the area in question is reversed depending on the brightness increasing/decreasing direction patterns. Accordingly,

5   brightness increase or decrease owing to embedded information is cancelled in the total sum ΣR of the pixel data brightness averages R obtained for the adjacent areas located on the four sides of the area in question respectively in the temporary groups G'. On the other

10 hand, since information is not embedded in the area H at all, the total sum ΣF of the pixel data brightness averages F obtained for the area in question respectively in the temporary groups G' does not include brightness increase or decrease owing to information embedding. As a result, a

15 difference generated between the total sum ΣF and the total sum ΣR is small.

Accordingly, it is possible to detect the area H in which the information is not embedded by obtaining the difference between the total sum ΣF and the total sum ΣR

20 obtained for the temporary groups G' with respect to the area Si.

Next, when the areas H in which information is not embedded are detected as described above, then a plurality of groups G, which are located on the image data and each

25 have a predetermined array specified by the rule stored in the group array/location rule storage part 312, are

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recognized based on the locations of the areas H on the image data. That array consists of: the areas T_1 - T_n in which digital watermark information b_1 - b_n is embedded respectively; the area J in which the information p

5 specifying the image data brightness increasing/decreasing direction pattern is embedded; and the area H in which information is not embedded.

Now, for example as shown in Fig. 6, it is assumed that digital watermark information b_1 - b_7 is embedded in

10 image data such that groups G are located one after another so as to cover all the image data, each group G consisting of the areas T_1 - T_7 in which digital watermark information b_1 - b_7 is embedded respectively, the area J in which information p is embedded, and the area H in which

15 information is not embedded, with those areas being allocated to 3 × 3 (nine in total) areas S in a predetermined array. Then, a case of an image shift caused by cutting this image data by upper one pixel line is considered.

20 In this case, the temporary groups G' are allocated as shown in Fig. 10. In the present embodiment, when digital watermark information is embedded in the image data, the groups G are located one after another on the image data so as to cover all the image data, each group G

25 consisting of the areas T_1 - T_7 in which the digital watermark information b_1 - b_7 is embedded respectively, the

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area J in which the information p is embedded, and the area
H in which digital watermark information is not embedded,
these areas being allocated to 3 × 3 (nine in total) areas
S according to the predetermined array. Accordingly, each
of the temporary groups G' inevitably includes the area H
in which information is not embedded.

Accordingly, by detecting the areas H in which
information is not embedded from the image data, it is
possible to recognize each of the groups G located on the
image data as shown in Fig. 11, based on the positions of
the areas H in the image data.

The information extracting part 305 extracts the
digital watermark information b_1 - b_n from the image data
embedded with the digital watermark information b_1 - b_n,
which is held in the image hold part 311, based on the
respective locations of the groups G recognized by the
group recognizing part 304.

In detail, first, the information p is extracted
from the area J in each group G recognized by the group
recognizing part 304, in order to find the brightness
increasing/decreasing direction pattern used for embedding
information in that group G. Here, in order to extract the
information p from the area J, a difference F - R between
an average brightness F of the pixel data within the area J
and an average brightness R of the pixel data in the
adjacent areas located on the four sides of the area J in

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question is examined. When the difference F - R is more

than or equal to a predetermined threshold +Th (set to a

slightly lower value than U used in embedding information),

it is judged that the information p embedded in that area

5   has a bit value 1. When, the difference F - R is less than

or equal to a predetermined threshold -Th, then it is

judged that the information p embedded in that area has a

bit value 0.

Next, when the value of the information p embedded

10   in the area J of each group G is ascertained, then, with

respect to an area T_i ($1 \leq i \leq n$), a difference between an

average brightness F for pixel data within that area and an

average brightness R for pixel data in the adjacent areas

located on the four sides of the area in question is

15   extracted from each group G, taking the brightness

increasing/decreasing direction pattern specified by the

mentioned information p into consideration. Here, the

consideration of the brightness increasing/decreasing

direction pattern specified by the information p means the

20   following. Namely, when the brightness

increasing/decreasing direction pattern specified by the

information p of a certain group G indicates that digital

watermark information b_i is embedded such that brightness

for an area T_i of the group G in question is increased by U

25   for a bit 1 and decreased by U for a bit 0, then, F - R is

extracted as the difference between the average F and the

average R. When the brightness increasing/decreasing

direction pattern indicates that the digital watermark

information b_i is embedded such that the brightness is

decreased by U for a bit 1 and increased by U for a bit 0,

5   then, R - F is extracted as the difference between the

average F and the average R. As a result, the difference

in the sign of the mentioned difference between the

averages for a bit value owing to the difference in the

pixel data brightness increasing/decreasing direction for a

10 bit value is cancelled.

When, with respect to an area T_i, the difference

between the average brightness F of the pixel data within

the area T_i and the average brightness R of the pixel data

in the adjacent areas located on the four sides of the area

15 in question is extracted for each group G as described

above, then, the total sum Z of the differences in question

is obtained and compared with a predetermined threshold W

(which is set to (a threshold Th set slightly lower than U

used for embedding the information) × (the number of the

20 groups recognized by the group recognizing part 304)) to

examine the bit value of the digital watermark information

b_i. For example, when the total sum Z is more than or

equal to the threshold +W, then the bit value of the

digital watermark information b_i is judged to be 1, and

25 when it is less than or equal to a threshold -W, then the

bit value of the digital watermark information b_i is judged

to be 0.

The above process is carried out for all the areas T_1 - T_n so as to extract the digital watermark information b_1 - b_n from the image data.

5   Next, a hardware configuration of the digital watermark information extracting apparatus to which the present embodiment is applied will be described.

The hardware configuration of the digital watermark information extracting apparatus of the present embodiment

10   is fundamentally same as the hardware configuration of the digital watermark information embedding apparatus shown in Fig. 7.   Namely, it is implemented on an information processing apparatus of general construction comprising CPU 201, a memory 202, an external storage unit 203 such as a

15   hard disk unit, another external storage unit 204, an input unit 205 such as a keyboard, an output unit 206 such as a display, and an interface 207 with the external storage units and input and output units.   Here, each part of the processing part 300 shown in Fig. 9 is realized as a

20   process that is substantiated on the information processing apparatus when the CPU 201 executes a program loaded onto the memory 202.   Further, in this case, the memory 202 and the external storage units 203, 204 are used as the storage part 310 shown in Fig. 9.

25   The above-mentioned program that is executed by the CPU 201 for substantiating the digital watermark

information extracting apparatus of the present embodiment
on the information processing apparatus is stored in the
external storage unit 203 in advance and loaded onto the
memory 202 as the need arises, so as to be executed by the
5   CPU 201. Or, the program may be loaded onto the memory 202
from a portable storage medium 208 such as CD-ROM through
the external storage unit 204 that handles the mentioned
portable storage medium 208, and then executed by the CPU
201. Or, the program may be once installed in the external
10   storage unit 203 from a portable storage medium 208 through
the external unit 204, and thereafter, loaded onto the
memory 202 from the external storage unit 203 as the need
arises, so as to be executed by the CPU 201. Or, the
program may be once downloaded into the external storage
15   unit 203 from a network through a network connecting
apparatus (not shown) and loaded onto the memory 202, or
directly loaded onto the memory 202 through a network, so
as to be executed by the CPU 201.

Here, the digital watermark information embedding
20   apparatus and the digital watermark information extracting
apparatus used in the digital watermark system of the
present embodiment may be implemented on the same
information processing apparatus.

Next, operation of the digital watermark extracting
25   apparatus to which the present embodiment is applied will
be described.

Fig. 12 is a flowchart for explaining operation of the digital watermark information extracting apparatus 3 shown in Fig. 9. This flow is started when the control part 302 cooperates with the input-output part 301 to make

5   image data embedded with the digital watermark information b_1 - b_n held in the image hold part 311.

First, the block dividing part 303 divides the image data held in the image hold part 311 into a plurality of areas S each having a size set by the block dividing part

10   303 of the digital watermark information embedding apparatus 1 (Step S3001).

Next, as previously described referring to Fig. 10, the group recognizing part 304 locates the temporary groups G', each of which has the same size and shape as the group

15   G specified by the rule stored in the group array/location rule storage part 312, in the image data divided into a plurality of areas S in the Step S3001, on a predetermined manner specified by the rule stored in the group array/location rule storage part 312 (Step S3002).

20   Next, as described above, the group recognizing part 304 detects the area H in which information is not embedded for each temporary group G' located on the image data (Step S3003).

Then, as previously described referring to Fig. 11,

25   based on the locations of the detected areas H on the image data, the group recognizing part 304 recognizes a plurality

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of groups G that are located on the image data and each
have the predetermined array specified by the rule stored
in the group array/location rule storage part 312 (Step
S3004). That array consists of: the areas T_1 - T_n in which
digital watermark information b_1 - b_n is embedded
respectively; the area J in which the information p
specifying the image data brightness increasing/decreasing
direction pattern is embedded; and the area H in which
information is not embedded.

When the group recognizing part 304 finishes the
recognition of the groups G, then the information
extracting part 305 extracts the information p from the
area J in each group G recognized by the group recognizing
part 304, and examines the bit value, so as to judge the
brightness increasing/decreasing direction patterns used in
each group G (Step S3005).

Next, the information extracting part 305 notes an
area T_i out of the areas T_1 - T_n in each group G recognized
by the group recognizing part 304 (Step S3006).

Next, with respect to a certain group G, the
information extracting part 305 obtains an average
brightness F of pixel data within the area T_i of that group
G (Step S3007), and then, obtains an average brightness R
of pixel data in the adjacent areas located on the four
sides of the area T_i in question (Step S3008). Then, with
respect to the group G in question, a difference between

the average F and the average R is obtained according to the pixel data brightness increasing/decreasing direction that is specified by the brightness increasing/decreasing direction pattern judged in Step S3005 and that is used in

5 embedding the digital watermark information b_i in the area T_i (Step S3009). In detail, when the brightness increasing/decreasing direction pattern for the group G in question indicates that the digital watermark information b_i has been embedded in the area T_i such that the brightness

10 is increased by U for a bit 1 and decreased by U for a bit 0, then, F - R is obtained as the difference between the average F and the average R. On the other hand, when the brightness increasing/decreasing direction pattern indicates that the digital watermark information b_i has

15 been embedded in the area T_i such that the brightness is decreased by U for a bit 1 and increased by U for a bit 0, then, R - F is obtained as the difference between the average F and the average R.

Next, when the processes of Steps S3007 - S3009 have

20 been finished for all the groups G recognized by the group recognizing part 304 with respect to the area T_i noted in Step S3006 (Step S3010), then, the information extracting part 305 obtains the total sum Z of the differences obtained for all the groups G in Step S3009 with respect to

25 the area T_i, and compares this total sum Z of these differences with the predetermined threshold W (which is

set to (a threshold Th set slightly lower than U used for embedding the information) × (the number of the groups recognized by the group recognizing part 304)) (Step S3011). When the total sum Z is more than or equal to the threshold +W, then it is judged that the digital watermark information b_i embedded in the area T_i of each group G is 1 (Step S3012). When the total sum Z is less than or equal to a threshold -W, then it is judged that the bit value of the digital watermark information b_i is 0 (Step S3013). Here, when the total sum Z is less than the threshold +W and more than the threshold -W, then it means that the digital watermark information b_i that should have been embedded in the area T_i is not embedded. In that case, it is possible that processing (for example, rotation processing or scaling processing) other than image shift has been carried out on the image data in which digital watermark information b_1 - b_n has been embedded by the digital watermark information embedding apparatus 1 of the present embodiment. Accordingly, after carrying out error processing (Step S3014), the present flow is ended.

When the processes of Steps S3006 - S3011 are finished for all the areas T_1 - T_n in which the digital watermark information is embedded (Step S3015), the information extracting part 304 makes the information hold part 313 hold the bit values of the digital watermark information b_1 - b_n, and the present flow is ended. The

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information b_1 - b_n held in this watermark information hold part 313 is outputted as the digital watermark information through the input-output part 301 as the need arises.

Hereinabove, the first embodiment of the present invention has been described.

According to the present embodiment, groups G each having a predetermined array consisting of areas T_1 - T_n in which digital watermark information b_1 - b_n is respectively embedded, an area J in which information p specifying an embedding format is embedded, and an area H in which information is not embedded, are located one after another to cover all the image data, and a plurality of areas S obtained by division of the image data are each allocated to some one of the areas T_1 - T_n, J, and H, so that the digital watermark information b_1 - b_n and the information p are embedded in the image data.

Accordingly, even when image shifting processing is carried out on image data in which digital watermark information b_1 - b_n is embedded as described above, and, as a result, X-Y coordinate locations of the area T_1 - T_n in which the digital watermark information b_1 - b_n is embedded are changed, it is possible to recognize each of the groups G located on the image data in question, as follows. Namely, by dividing the image data, on which the image shifting processing has been carried out, into a plurality of areas S, and by detecting the areas H, in which

information is not embedded, out of these areas S, it is possible to recognize each of the groups G located on the image data in question, based on the X-Y coordinates of the detected areas H in the image data.

5   Particularly, in the present embodiment, temporary groups G' (each having the same shape and size as the group G used in embedding the digital watermark information) are located on the image data (in which the digital watermark information b_1 - b_n has been embedded) according to the

10   location rule employed for those groups G in embedding the digital watermark information. Next, by examining the areas S for each of the groups G' located one after another on the image data as described, the area H in which information is not embedded is detected. Then, each of the

15   groups G located on the image data in question is recognized based on the X-Y coordinate value of the detected area H in the image data, and thereby, the areas T_1 - T_n in which the digital watermark information b_1 - b_n has been embedded are detected on the image data.

20   Namely, according to the present embodiment, in specifying the detected positions of the areas T_1 - T_n on the image data in which the digital watermark information b_1 - b_n is embedded, it is sufficient to calculate a difference $|\Sigma F - \Sigma R|$, a number of times corresponding to

25   the number of the areas S contained in each temporary group G' so as to examine if information is embedded or not. As

a result, determination of the detected locations of the areas T_1 - T_n on the image data in which the digital watermark information b_1 - b_n is embedded can be carried out at high speed. This effect is particularly remarkable in

5 the case that, when processing (for example, rotation processing and scaling processing) other than image shift is carried out on the image data in which digital watermark information b_1 - b_n has been embedded, the digital watermark extracting apparatus is so constructed that it can specify

10 the detected locations of the areas T_1 - T_n on the image data taking such processing into consideration.

The present inventors already invented and filed an application for a patent (Japanese Patent Application No. 10-343119, US serial number 09/388,447 filed on September

15 2, 1999) on a method of extracting digital watermark information b_1 - b_n from the image data that has been subjected to reversible geometric transformation (transformation for which the original image data before the transformation can be recovered) after the digital

20 watermark information b_1 - b_n was embedded. This method is carried out by repeating a process of investigating embedded locations in the X-Y coordinates (determined in advance with a person who embeds the information in the image data) in the image data for each of the digital

25 watermark information b_1 - b_n while carrying out the same transformation processing on the image data as the left-

right reversal, scaling processing, and rotation processing that might have been carried out on the image data in question, until the corresponding digital watermark information b_1 - b_n is detected from all the embedded

5   locations.

This method can be applied to the image shift processing. Namely, by repeating a process of changing the origin of the image data in the X-Y coordinates while carrying out the process in combination with the above-

10   mentioned transformation processing, it is also possible to extract the digital watermark information b_1 - b_n from the image data on which the reversible geometric transformation and image shift processing have been carried out after embedding of the digital watermark information b_1 - b_n.

15   However, in that case, the number of times of search for specifying the detected location of each of the digital watermark information b_1 - b_n increases extremely and a burden on the processing increases rapidly.

Figs. 13A and 13B show flowcharts for explaining the

20   difference in processing burdens between the cases of Figs. 13A and 13B. In the case of Fig. 13A, the method of repeating the same transformation processing as the left-right reversal, scaling processing, and rotation processing that might have been carried out on the image data until

25   the digital watermark information b_1 - b_n is extracted is applied to the transformation by image shift processing.

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In the case of Fig. 13B, the mentioned method is combined
with the extract method of the present embodiment.

In Fig. 13A, when rotating processing (S5002) on the
image data is carried out up to 360 degrees, increasing by

5   1 degree, and scaling processing (S5003) is carried out in
the range of the magnification ratio of 0.5 - 2.0 at
intervals of 0.1, then the number of search for extracting
the digital watermark information b_1 - b_n required for
combination of left-right reversal (S5001), rotating

10 processing (S5002), and scaling processing (S5003) becomes
2 (for left-right reversal) × 360 (for rotation processing)
× 21 (for scaling processing) = 15,120, at most. When,
image shift processing (S5004) is carried out in addition,
the number of search increases rapidly. Namely, the number

15 of pixels constituting the image data is enormous, and the
location of the origin O in the X-Y coordinates required
for specifying each pixel data is not always located on the
image data (for example, as shown in Fig. 18, it is
possible that, when a part of the image data is cut, the

20 origin O in the original data before the cut is located in
the cut part). As a result the number of search for the
location of the origin O in the X-Y coordinates becomes
enormous. The above-mentioned number of search 15,120 is
multiplied by this number, and thus the number of times for

25 carrying out the routine (S5006 - S5009) of the flow
becomes enormous.

On the other hand, as shown in Fig. 13B, according to the case to which the present embodiment is applied, the number of time for carrying out the routine of the flow is not fundamentally changed from the case in which the

5   countermeasure for the image shift processing is not taken. Here is employed S5014 (the flow of Fig. 11) instead of the routine (S5004, S5006) of Fig. 13A.

As described above, the present embodiment is particularly effective for the case that, when geometric

10   transformation processing other than image shift is carried out on image data in which digital watermark information b_1 - b_n is embedded, the digital watermark extracting apparatus is constructed such that detected location of the areas T_1 - T_n on the image data can be specified taking such

15   processing into consideration.

Further, the above embodiment has been described with respect to the case that, when digital watermark information is embedded in image data, one area H in which information is not embedded is allocated in each group G.

20   However, a plurality of areas H in which information is not embedded may be allocated in each group G. In that case, as shown in Fig. 14, when those areas H are allocated asymmetrically in the vertical and horizontal directions in each group G, then, by investigating the arrangement of

25   those areas H in extracting the information, it is possible to detect left-right reversal carried out on the image data

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as shown in Fig. 15 and rotation carried out on the image

data as shown in Fig. 16, at the same time.

Further, instead of a plurality of areas H in which

information is not embedded and which are asymmetric in the

5   vertical and horizontal directions as shown in Fig. 14,

areas each embedded with a bit value 1 may be allocated,

for example. In that case, by detecting the areas having

the bit value 1 and arranged in that way, locations of the

groups G on the image data can be specified.

10   Further, in the present embodiment, as the

brightness increasing/decreasing direction patterns applied

to each group G in embedding digital watermark information

in image data, the case in which the two patterns as shown

in Fig. 4 are employed has been described. However, three

15   or more patterns may be used. In that case, information p_1

- p_k (k depends on the number of the patterns) specifying

those three or more patters may be allocated in the areas

of each group G. Further, any combination of patterns may

be employed as long as the difference between the total sum

20   ΣF of the pixel data brightness averages F with respect to

the area H in which information is not embedded for every

groups G and the total sum ΣR of the pixel data brightness

average R with respect to the adjacent areas located on the

four sides of the area in question for every group G is not

25   affected by increase or decrease of brightness owing to the

information embedded in these adjacent areas. Further,

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when the area H in which information is not embedded can be

detected in some way without being affected by information

embedded in those adjacent areas located on the four sides

of the area H in question, then one kind of pattern may be

5   used. In that case, the area J in which the information p

is embedded becomes unnecessary. Further, in that case,

extraction of digital watermark information from image data

is carried out as follows. Namely, for example, with

respect to an area T_i ($1 \le i \le n$) adjacent to the area H in

10   which information is not embedded, a difference $F - R$

between an average brightness F for pixel data in the area

in question and an average brightness R for pixel data in

the area H in which information is not embedded is obtained

for each group G. Then, the total sum $\Sigma(F - R)$ of the

15   obtained differences $F - R$ is compared with a threshold, in

order to judge the bit value of the information embedded in

the mentioned area T_i. Next, with respect to an area T_j (1

$\le j \le$, $j \ne i$) adjacent to the area T_i whose bit value of the

embedded information has been judged, a difference $F - R'$

20   between an average brightness F for pixel data in the area

T_j in question and a value R' obtained by subtracting the

brightness increase or decrease according to the bit value

of the information embedded in the area T_i from the average

brightness R for the pixel data in the area T_i is obtained

25   for each group G. Then, the total sum $\Sigma(F - R')$ of the

obtained differences $F - R'$ is compared with a threshold in

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order to judge the bit value of the information embedded in the mentioned area T_j. When the digital watermark information $b_1 - b_n$ is extracted from the image data by carrying out this process for all the areas $T_1 - T_n$ in which

5 the digital watermark information $b_1 - b_n$ is embedded, then the bit value of the information embedded in the area T_i can be judged with accuracy without being affected by the information embedded in the areas adjacent to the area T_i.

Further, in the present embodiment, information is

10 embedded in an area by increasing or decreasing brightness of the pixel data in that area. However, instead of brightness, another data value may be changed in order to embed information in the area in question.

Further, in the present embodiment, a static image

15 data is taken as an example of an object in which digital watermark information is embedded. Of course, however, the present invention can be applied to a dynamic image. In that case, digital watermark information may be embedded for each frame or field image data as a unit. Further,

20 when a dynamic image has been subjected to inter-frame or inter-field predictive coding, such as MPEG, then the digital watermark information may be embedded in an I-frame.

Further, digital watermark information embedded in

25 image data according to the present embodiment may be used as a watermark for calibration in detecting rotation or

scaling carried out on the image data in question.

Namely, after the digital watermark information is embedded in image data as in the present embodiment, digital watermark information on, for example, copyright is embedded in the image data by another method (for example, in the method described above as the conventional technique, by changing color information instead of brightness increasing or decreasing in embedding information).

Then, for extracting the digital watermark information such as copyright from the image data, first a difference in brightness from the adjacent pixel data is investigated for each pixel data constituting the image data, in order to detect the areas in which information is not embedded. Next, reversal processing and rotation processing are carried out so that the size and arrangement pattern of the detected areas become same as the size of the area S and the arrangement pattern of the areas in which information is not embedded, the pattern being specified by the area allocation pattern within each group G and the arrangement pattern of the groups G on the image data, when the digital watermark information was embedded in the image data as in the above-described embodiment. This operation recovers the image data when the digital watermark information was embedded. By previously knowing the relative positions of the locations at which the

digital watermark information such as copyright is embedded from the above-mentioned area in which information is not embedded, the information in question on copyright etc. can be extracted from the image data.

5   As described above, according to the present invention, even when the image shift is carried out on image data in which digital watermark information is embedded, the locations in which digital watermark information is embedded can be specified from the image

10   data in question on which the image shift is carried out.

While the present invention has been described in detail and pictorially in the accompanying drawings, it is not limited to such details, since many changes and modifications recognizable to those of ordinary skill in

15   the art may be made to the invention without departing from the spirit and the scope of thereof.